This appendix outlines the methodology used in developing an estimate of the potential NO_x emission reductions from selected categories of the New Jersey Clean Energy Program. Excel workbooks were the primary calculation tool used in this process. The NJ Clean Energy Protocols and NREL's PVWATTS tool provided key inputs.

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1. Assessment of 2005 Electricity Savings and Emission Reductions from Selected Categories of the NJ Clean Energy Program

	2005 Electricity Savings (MWh)								
	2002 Projects		2003 Projects		2004 Projects	Summer Fraction		2005 Summer	2005 Summer
	Original	Discounted	Original	Discounted	Original	On-Peak	Off-Peak	MWh	NOx (tons)
Residential HVAC	15,703	11,345	14,621	12,428	15,499				
CAC	15,373	11,107	14,299	12,154	15,196	64.9%	35.1%	38,457	28.84
Heat Pumps	330	238	322	273	303	28.0%	22.0%	407	0.31
Residential New Construction	3,262	2,357	4,773	4,057	4,551	21.0%	22.0%	4,715	3.54
Room Air Conditioning	0	0	1,432	1,217	1,377	65.1%	34.9%	2,594	1.95
Lighting	0	0	61,630	52,386	95,206	21.0%	22.0%	63,464	47.60
Clothes Washers	0	0	0	0	740	24.5%	12.8%	276	0.21
Comfort Partners	5,196	3,754	5,774	4,908	6,995	21.0%	22.0%	6,733	5.05
C&I New Construction	144,635	104,499	11,760	9,996	31,538	24.0%	19.0%	62,794	47.10
C&I Retrofit	0	0	179,679	152,727	163,631	24.0%	19.0%	136,034	102.03
New School Construction & Retrofit	0	0	5,908	5,022	8,975	24.0%	19.0%	6,019	4.51
EE Subtotal	168,796	**121,955**	285,577	**242,740**	**328,512**			**321,493**	**241.12**
PV	0	0	0	0	3,003			1,505	1.13
Total	168,796	**121,955**	285,577	**242,740**	**331,515**			**322,999**	**242.25**

EE Degradation Factor	15%
RE Degradation Factor	5%

EE Summer Fraction	46.3777%
PV Summer Fraction	50.1321%

This table illustrates the overall electricity savings for 2005 resulting from selected categories of the NJCEP implemented from 2002 through 2004. The table also includes the summer electricity savings and summer NO_x emission reductions resulting from these project categories. The base figures are the annual electricity savings resulting from each category of measure, as identified in the quarterly reports of the New Jersey Board of Public Utilities on the Clean Energy Program. The annual electricity savings from the energy efficiency projects of 2002 are multiplied by the square of (1-degradation factor), or 0.7225. The savings from the 2003 projects are multiplied by (1-degradation factor), or 0.85. The savings from the 2004 projects are fully credited for the summer of 2005. The total annual savings (the sum of the 2004 value and the discounted 2002 and 2003 values) are then multiplied by the sum of the summer season allocation factors. For example, clothes washers are assumed to

achieve 24.5%[1] of their annual energy savings in the summer peak period and 12.8% of their annual energy savings in the summer off-peak period, for a total of 37.3% of their annual savings in the summer.

For PV systems, the discount factors are not applied (all systems are assumed to have been installed in 2004), and the allocation factor is based on the input of specific system characteristics into NREL's PVWATTS tool. This tool calculates the monthly output of systems based on size, location, and orientation. A flat-roof PV system will generate 56.1% of its annual electricity during the May to September period, whereas a south-facing system at 45° tilt will generate only 45.5% of its annual electricity in that time period (but about 15% more than the flat-roof system over the course of the year).

Summer electricity savings were derived on a measure-specific basis, using the allocation factors from the NJ Clean Energy Protocols or using appropriate surrogates (such as the OTC Emission Reduction Workbook or PVWATTS). The combination of energy efficiency measures implemented in 2002 to 2004 have a weighted seasonal allocation factor of 46.38%. This factor is used for energy efficiency measures implemented in future years, as the exact combination of measures to be implemented is not known at this time. The PV systems installed have a weighted seasonal allocation factor of 50.13%, with generation of 1505.455 MWh per summer (May-September) and 3002.979 MWh per year.

NO_x emission reductions for 2005 are generated using the allowance allocation factor of 1.5 lbs/MWh. See Appendix 4 for our analysis establishing that 2005 emission reductions will likely exceed this value.

2. Projection of Future NO_x Emission Reductions and Sensitivity Analysis

Step 1: Defining the Scenarios

Base Case	**EE**	**PV**
Program Growth	20%	40%
Degradation Factor	15%	5%
Grid Improvement	5%	5%

Low Growth	**EE**	**RE**
Program Growth	10%	30%
Degradation Factor	15%	5%
Grid Improvement	5%	5%

Continued Savings	**EE**	**RE**
Program Growth	20%	40%
Degradation Factor	5%	2.5%
Grid Improvement	5%	5%

Clean Grid	**EE**	**PV**
Program Growth	20%	40%
Degradation Factor	15%	5%
Grid Improvement	10%	10%

Full RE	**EE**	**RE**
Program Growth	20%	41%
Degradation Factor	15%	5%
Grid Improvement	5%	5%

These tables establish the variables for the analysis of future NO_x emission reductions. The four scenarios other than the "Base Case" serve to illustrate the sensitivity of the analysis to the various assumptions. "Grid Improvement" refers to decreases in the avoided NO_x rate after 2008; rates through 2008 were identified by NJ DEP.

[1] We consider our results to be accurate to no more than two significant figures. However, in order to reduce rounding errors, we carry forward up to seven digits in our calculations, only rounding off the final result.

Step 2: Identifying Annual Electricity Savings and Generation

EE MWh	**Year of Savings**									
Year of Project	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
2002	168,796	143,477	121,955	103,662	88,113	74,896	63,661	54,112	45,995	39,096
2003		285,577	242,740	206,329	175,380	149,073	126,712	107,705	91,549	77,817
2004			328,512	279,235	237,350	201,747	171,485	145,763	123,898	105,313
2005				394,214	335,082	284,820	242,097	205,782	174,915	148,678
2006					473,057	402,099	341,784	290,516	246,939	209,898
2007						567,669	482,518	410,141	348,620	296,327
2008							681,202	579,022	492,169	418,343
2009								817,443	694,827	590,603
2010									980,932	833,792
2011										1,177,118
	168,796	*429,054*	*693,208*	*983,441*	*1,308,982*	*1,680,303*	*2,109,460*	*2,610,484*	*3,199,843*	*3,896,985*
PV MWh										
Year of Project	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
2002	0	0	0	0	0	0	0	0	0	0
2003		0	0	0	0	0	0	0	0	0
2004			3,003	2,853	2,710	2,575	2,446	2,324	2,207	2,097
2005				4,204	3,994	3,794	3,605	3,424	3,253	3,090
2006					5,886	5,592	5,312	5,046	4,794	4,554
2007						8,240	7,828	7,437	7,065	6,712
2008							11,536	10,960	10,412	9,891
2009								16,151	15,343	14,576
2010									22,611	21,481
2011										31,656
	0	*0*	*3,003*	*7,057*	*12,590*	*20,201*	*30,727*	*45,342*	*65,686*	*94,057*

These tables illustrate the annual electricity savings or generation achieved by the energy efficiency measures and photovoltaic systems. The shaded boxes illustrate the most recent measures implemented. The unshaded boxes represent continuing electricity savings from measures previously implemented, and reflect the degradation factor (in the base case, 15% for energy efficiency, 5% for photovoltaic systems).

The savings from the most recent projects increase each year according to the growth factor for each scenario. For example, New Jersey expects that the budget for energy efficiency programs will grow by about 10% each year and that the cost-effectiveness of the program will grow by about 10%. Therefore, these tables include energy efficiency program growth of about 20% per year in the base case. The 2006 electricity savings from the 2005 energy efficiency projects are 20% larger than the 2005 savings from 2004 energy efficiency projects.

Steps 3 and 4: Identifying Summer Electricity Savings or Generation and Identifying Summer NO_x Emission Reductions

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
EE Summer Fraction	0.4637767	0.4637767	0.4637767	0.4637767	0.4637767	0.4637767	0.4637767	0.4637767	0.4637767	0.4637767
PV Summer Fraction	0.501321	0.501321	0.501321	0.501321	0.501321	0.501321	0.501321	0.501321	0.501321	0.501321
Summer Energy Savings (MWh)	78,284	198,985	322,999	459,635	613,387	789,413	993,723	1,233,412	1,516,942	1,854,483
Projected NO_x rate (lb/MWh)	1.85	1.85	1.65	1.65	1.24	0.97	0.92	0.88	0.83	0.79
Credited NO_x rate	1.50	1.50	1.50	1.50	1.24	0.97	0.92	0.88	0.83	0.79
Credited NO_x Emissions (tons)	59	149	242	345	380	383	458	540	631	733

These tables translate the identified annual electricity savings and generation into summer season savings and generation, as well as NO_x emission reductions. First, the summer season allocation factors are applied. For energy efficiency, we multiply annual energy savings by the summer fraction of 2005 annual electricity savings (from measures implemented in 2002 to 2004). For photovoltaic systems, we multiply annual generation by the summer fraction identified by the PVWATTS tool for the systems in the CORE database (this accounts for orientation and inclination).

Then, the identified summer energy savings and generation are multiplied by the credited NO_x emissions rate. The rate applied is the lesser of 1.5 lbs/MWh or the projected NO_x emissions rate. The projected NO_x emissions rate for 2003-2008 is based on data provided by NJ DEP; for 2009-2012, it is the previous year's rate decreased by the "grid improvement" factor. For the base case, this factor is 5% per year. *New Jersey will need to conduct an analysis of the likely impact of CAIR and other regulations to more accurately project the relevant NO_x emission factors.*

PVWatts Methodology

Bin	Orientation			Tilt			Summer Generation			Annual Generation		Summer
	Min	Max	Assumed	Min	Max	Assumed	kWh/kW	kW	kWh	kWh/kW	kWh	Ratio
1	Any	Any	**0**	0	9	**0**	605	361.38	218,635	1079	389,929	56%
2	80	120	**100**	10	19	**15**	598	29.465	17,620	1091	32,146	55%
3	121	160	**140**	10	19	**15**	616	35.748	22,021	1176	42,040	52%
4	161	200	**180**	10	19	**15**	626	90.218	56,476	1209	109,074	52%
5	201	240	**220**	10	19	**15**	618	42.549	26,295	1172	49,867	53%
6	241	280	**260**	10	19	**15**	599	11.326	6,784	1084	12,277	55%
7	80	120	**100**	20	29	**25**	578	54.572	31,543	1071	58,447	54%
8	121	160	**140**	20	29	**25**	606	176.498	106,958	1203	212,327	50%
9	161	200	**180**	20	29	**25**	620	309.574	191,936	1253	387,896	49%
10	201	240	**220**	20	29	**25**	611	133.653	81,662	1197	159,983	51%
11	241	280	**260**	20	29	**25**	582	40.28	23,443	1061	42,737	55%
12	80	120	**100**	30	39	**35**	551	18.562	10,228	1035	19,212	53%
13	121	160	**140**	30	39	**35**	587	113.235	66,469	1201	135,995	49%
14	161	200	**180**	30	39	**35**	596	698.99	416,598	1263	882,824	47%
15	201	240	**220**	30	39	**35**	588	125.419	73,746	1192	149,499	49%
16	241	280	**260**	30	39	**35**	555	63.552	35,271	1023	65,014	54%
17	80	120	**100**	40	49	**45**	516	9.135	4,714	983	8,980	52%
18	121	160	**140**	40	49	**45**	554	52.39	29,024	1173	61,453	47%
19	161	200	**180**	40	49	**45**	563	82.963	46,708	1241	102,957	45%
20	201	240	**220**	40	49	**45**	556	56.265	31,283	1162	65,380	48%
21	241	280	**260**	40	49	**45**	522	15.404	8,041	970	14,942	54%
Total								2521.178	1,505,455		3,002,979	50.1321%

This table illustrates the process used to identify the generation from the PV systems in the state's CORE database. There were a total of 344 systems with a total capacity of 2,521.178 kW (see Appendix 2). The project team considered that it would be unnecessarily burdensome to evaluate every single system through PVWATTS, and determined that such a detailed evaluation would provide only limited value (with any change being relegated to non-significant digits in the final analysis). Therefore, the PV projects were grouped according to orientation and inclination. The project team evaluated a model 1-kW system for each group in PVWATTS to identify the annual and summer (May to September) kWh/kW ratio. The summer ratio was multiplied by the capacity within that "bin" to give the summer generation for that bin. The total summer generation was found to be 3,002.979 MWh per year for the projects in the CORE database.

The project team evaluated three different locations in New Jersey using PVWATTS. The two outlying locations had 4% higher and 4% lower summer generation than the mid-range location. We therefore modeled all systems as if located at the mid-range location. The initial assumption that all PV systems were flat-roof would have overestimated the summer generation by about 1.3% (but underestimated annual generation). Since that 1.3% error is only about 30 pounds of NO_x for 2005, even this rough breakdown by orientation and inclination is unnecessary. Similarly, any error caused by the assumption of a single representative location is also negligible.

Scenario: Full Renewable Energy Goal Met

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
EE Summer Fraction	0.4637767	0.4637767	0.4637767	0.4637767	0.4637767	0.4637767	0.4637767	0.4637767	0.4637767	0.4637767
PV Summer Fraction	0.501321	0.501321	0.501321	0.501321	0.501321	0.501321	0.501321	0.501321	0.501321	0.501321
Other RE Summer Fraction	0.434091	0.434091	0.434091	0.434091	0.434091	0.434091	0.434091	0.434091	0.434091	0.434091
Summer Energy Savings (MWh)	78,284	198,985	322,999	477,500	655,576	865,085	1,115,850	1,420,342	1,794,610	2,259,530
Projected NO_x rate (lb/MWh)	1.85	1.85	1.65	1.65	1.24	0.97	0.92	0.88	0.83	0.79
Credited NO_x rate	1.50	1.50	1.50	1.50	1.24	0.97	0.92	0.88	0.83	0.79
Credited NO_x Emissions (tons)	59	149	242	358	406	420	514	622	746	893
EE	59	149	241	342	376	378	451	530	617	714
Wind/Biomass	0	0	0	13	26	37	56	82	115	159
PV	0	0	1	3	4	5	7	10	14	19

	2005	2006	2007	2008	2009	2010	2011	2012
PV installed in previous year (kW)	2,521	3,555	5,014	7,071	9,972	14,063	19,833	27,970
Cumulative PV at beginning of year (kW)	2,521	6,076	11,090	18,161	28,133	42,197	62,030	90,000
Effective PV at beginning of year (kW)	2,521	5,950	10,667	17,204	26,316	39,064	56,944	82,067
Other RE installed in previous year (kW)		8,535	12,036	16,975	23,939	33,760	47,611	67,144
Cumulative other RE at beginning of year (kW)		8,535	20,571	37,546	61,484	95,244	142,855	210,000
Effective other RE at beginning of year (kW)		8,535	20,144	36,112	58,245	89,093	132,249	192,781
Wind MWh		13,084	30,881	55,359	89,289	136,579	202,738	295,533
Biomass MWh		28,037	66,174	118,627	191,334	292,669	434,438	633,285
Summer MWh		17,850	42,131	75,526	121,816	186,333	276,592	403,192

The "Full RE" scenario has several differences from other analyses. It assumes that New Jersey meets its goals of 90 MW of PV and 210 MW of other renewable energy by the end of 2011. The "program growth" rate for renewable energy in this case is actually 41%, selected to allow the cumulative installed capacity of PV to grow from 2.521 MW through 2004 (CORE program only) to 90 MW by the end of 2011. New Jersey would need to install 8.535 MW of non-PV renewable energy in 2005 to achieve a cumulative 210 MW installed by the end of 2011 with a 41% growth rate. For purposes of this analysis, we assume that installation and growth rate to occur.

Assumptions for "Full RE" case

Fraction of Wind	50%
Fraction of Biomass	50%
Wind Capacity Factor	35%
Wind Summer Fraction	40%
Biomass Capacity Factor	75%
Biomass Summer Fraction	45%
Overall Summer Fraction	43.41%

"Program growth" applies to the capacity of renewable energy systems as well as their annual generation, assuming that new systems will have the same capacity factor as current systems. "Effective PV at beginning of year" is the previous year's effective capacity times the degradation factor plus the most recent capacity additions. The same methodology is used for other renewable energy. Assumptions about the installed non-PV renewable energy are indicated in the table above. These give an effective summer allocation factor. Emission reductions for EE, PV, and other RE are calculated separately by multiplying together the annual generation, the summer allocation factor, and the credited NO_x rate. Biomass electricity, which in New Jersey typically consists of landfill gas energy projects, was assumed to have no net NO_x emissions. Direct emissions were assumed to be equal to the avoided flaring emissions. This is not always the case; however, if NJCEP wishes to achieve the maximum possible emission reductions, it will focus its efforts on landfill gas systems that produce fewer NO_x emissions, such as microturbines or fuel cells.